Appendix K
North Test Cell Pilot Unit Evaluation

APPENDIX K

North Test Pilot Unit Evaluation

The following technical memo presents the results of an on-site evaluation of the Managed Wetlands Project pilot units conducted between May 3rd through the 5th 2000. The evaluation was conducted to determine causes for high total dissolved phosphorus concentrations (in excess of the 10 µg/L P target) being discharged from the chemical treatment processes into the polishing wetlands. In addition the process units were experiencing excessive solids carry over from the plate settlers which in turn has been a contributing factor in TP concentrations above the target of 10 µg/L P.

The main objectives of the on-site evaluation were to determine what process modifications could be implemented to reduce total dissolve phosphorus (TDP) concentrations in the finished water prior to discharge into the polishing wetlands and to reduce solids carry over from the plate settlers. This technical memo presents the results of the evaluation in sections based on the two main objectives titled, Excessive Floc Overflow and Excessive TDP, and sections titled Sample Analysis Results and Recommendations.

K.1 Excessive Floc Overflow

The following presents a description of process modifications evaluated for reduction of excessive floc overflow from the plate settlers. The evaluations were qualitative in nature using visual comparison of changes in the pilot process and batch settling.

1. **Chemical Addition Points.** The chemical addition points of all units were adjusted to maximize dispersion of the chemicals. The PACL addition point was moved from the first rapid mix chamber to the splitter box. The ferric chloride addition point was changed to disperse at approximately one inch from the impeller of the first rapid mix chamber, while the sodium hydroxide was injected into the raw water line up-stream of the chamber. The polymer addition point was moved to disperse at approximately one inch above the impeller of the second rapid mix chamber. While improvement to solids formation and settling was not evident, it is reasonable to believe that dispersion of chemicals has been enhanced.

2. **Mixer/Flocculator Modifications.** A larger impeller was evaluated in the polymer mixing chamber with the result of excessive vibration to the motor and excessive turbulence which effected the flocculation basin. The flocculation basin flocculator speed was reduced in the basins with marginal improvement on floc formation. The flocculator for the PACl pilot unit was reversed in rotational direction to mirror the direction of the ferric chloride unit. The rotation change was made to counter the direction of flow from the polymer chamber, thereby reducing the chance of short-circuiting. The combination mixing direction change and reduction of flocculator speed appeared to slightly improve floc formation.

3. **Chemical Dose Rates.** The calibration procedure and feed rates of all chemicals were checked and verified as correct. The polymer day tank concentration and mixing

protocol was verified. It was recommended that a small mixer be used on "neat" liquid polymer to ensure a homogeneous solution before make-up of day tank solution. The dose of the N-1986 was varied from 0.25 mg/L to 1.5 mg/L with two coagulant dose concentrations of 1.5 meq/L (14 mg/L Al, 28 mg/L Fe) and 2.5 meq/L (23 mg/L Al, 46 mg/L Fe). Increasing the polymer dose slightly improved floc formation. However it was not significantly improved and little or no improvement was seen in settling rate. Increasing the coagulant dose in combination with the N-1986 polymer improved the floc characteristics slightly.

4. **Excessive Hydraulic Loading Rate.** The effective horizontally projected settling area of the plates was verified as 220 ft^2 by direct measurement. The loading rate was determined to be approximately 38 gpm/220 ft^2 (0.17 gpm/ft^2) and was not considered excessive based on historical applications, previous batch testing, and results observed by the CT/SS test group.

5. **Polymer Type Evaluation.** Two additional polymers were evaluated by addition to the North pilot units. A high charge and high molecular emulsion (Cytec AF-126) was evaluated first on the PACl pilot unit. This product's effect was relatively fast and apparent with significant improvement in discrete floc formation and larger floc size. A significant reduction in solids carry-over from the settler was not apparent. However, hindered sludge settling and the relative short term of the evaluation may have masked settling improvements. The high molecular weight, high charge, dry polymer used successfully by the CT/SS team (Cytec A-130) was applied to both North site pilot units. There was a significant enough improvement in floc particle formation that it was selected for a longer term evaluation at both sites and all pilot units. However, reductions of solids carry-over from the plate settlers were only marginal with the units in recirculation mode.

6. **Hindered Settling.** Samples were collected in a 2L graduated settleometer from the flocculation basin, allowed to settle and measured for the rate of settling. When using the N-1986 polymer the floc particles grew as the initial turbulence subsided. Hindered settling (type 3 settling) was observed with a clear, identifiable interface developing between the upper (clear) region and the lower hindered-settling region. The A-130 samples appeared to be only slightly better, however the short time of operation may not have been sufficient to condition the solids within the system. Samples collected immediately from the polymer mixing chamber, representing single pass with no sludge recycle, settled significantly faster in a flocculent settling (type 2 settling) mode. It was recommended that if settling did not improve within a week or two of operation, then reducing the sludge age to discourage hindered settling and encourage flocculent settling should be considered.

K.2 Excessive TDP

1. **Sample Collection.** Sample collection procedures were reviewed with no apparent discrepancies in technique.

2. **Filter Test.** To test if solids were passing through the 0.45 µm filter used for sample preparation two samples were collected from each clarifier of the north pilot units. One

was decanted before filtering, the other was not. The results indicated that the solids concentration before filtering did not effect TDP concentration, indicating that the hydroxide solids do not appear to be passing the 0.45 µm filter.

3. **Coagulant Contamination.** Grab samples of PACl and ferric chloride were diluted down to 1 meq/L (9 mg/L Al, 18.6 mg/L Fe),and analyzed for TDP (in duplicate) and the respective metal concentration. An aliquot of the dilution water was also measured for TDP. All the results are presented in the Sample Analysis section. The dilution water was reported less than the detection level of 4 µg/L P. The TDP was measured at 5 and 12 µg/L P in the PACl. The TDP was measured at 9 and 10 µg/L P in the ferric chloride. The metal concentrations were measured at 8.06 mg/L Al for the PACl and 2.86 mg/L Fe for the ferric chloride dilutions. The iron measurement is significantly low, however samples were filtered and iron precipitate was likely removed prior to analysis. The analysis indicates that there appears to be measurable phosphorus in the coagulants.

4. **Feedback From Sludge.** Samples were collected and measured for TDP from the ferric chloride pilot unit clarifier and from the outflow of the downstream sludge storage reservoir. The clarifier concentration was measured at 25 and 20 µg/L P with the out-flow of 24 and 30 µg/L. Since there is a 5 µg/L P variability it is difficult to assess if there is significant feedback from the sludge. It does however appear to indicate that sludge feedback is not significant, and is not the single cause of excessive TDP (over the 10 µg/L target) in the outflow.

K.3 Sample Analysis Results

During the on-site evaluation of Managed Wetlands Project pilot units between May 3rd through the 5th, 2000, process modifications were evaluated and limited grab samples were collected from the treatment process trains. This section presents the results of the limited sampling regime with the objectives and conclusions derived from the analytical results. The results of the TDP and metals analysis of samples collected from the North site pilot units and coagulants are presented in Table 1. Results of calculations for TDP reduction by the pilot unit coagulation, flocculation and settling processes is presented in Table 2. The TDP reduction is based on the raw with and without the contribution of TDP by the coagulant dose.

K.3.1 Objectives

The objectives of the limited sampling regime were to determine:

1. The reduction of TDP after the clarification process at the initial condition of 1.5 meq/L (13.5 mg/L Al, 27.9 mg/L Fe) of coagulant
2. The reduction of TDP after the solids storage tank
3. If feed back of TDP from sludge storage was occurring
4. If the coagulants were contributing TDP to the process
5. If the coagulation process was efficient by measuring residual metal concentrations

6. If high solids concentration was increasing TDP from fines passing through filter used for sample preparation
7. The reduction of TDP after the clarification process with an increase in coagulation dose

K.4 Conclusions

1. At a coagulant dose of 1.5 meq/L (13.5 mg/L Al, 27.9 mg/L Fe) the TDP was not reduced below the 10 µg/L target immediately after the clarification process.
2. The TDP concentration of the solids storage tank effluent was not significantly different from the clarified samples indicating that feed back from the sludge was not occurring.
3. High solids did not appear to effect TDP after filtering (no discernable P bearing solids appear to pass the 0.45 µm filter.)
4. The dissolved residual metals concentration indicates that the coagulation process is relatively efficient.
5. The coagulants had measurable amounts of TDP ranging from 5 to 10 µg/L P at a dose of 1 meq/L (9 mg/L Al, 18.6 mg/L Fe)
6. Increasing the coagulant doses resulted in a measured TDP of 12 µg/L P. While this concentration is a historical low for the pilot units it is not clear that the increase in coagulant dose resulted in the reduction of TDP.

K.5 Recommendations

The following are recommendation for future course of actions should excessive solids and TDP issues continue.

- Consider reducing sludge age
  - To promote flocculent settling
  - Extended sludge age does not appear to be providing excess P adsorptive capacity
- Continue to test the A130 product which was effective for CT/SS.
- Verify that coagulants are free from contaminants
  - Submit serial dilutions
- Split samples among several laboratories to evaluate laboratory reliability

Results

TABLE 1
Total Dissolved Phosphorus and Metal Concentrations

Sample ID	Total Dissolved Phosphorus (µg/L P)		
	Sample	Duplicate	Difference
5/3/00 – Inflow	62		
5/3/00 – Clarifier FeCl3	25	20	5
5/3/00 – Outflow FeCl3	24	30	6
5/4/00 – Inflow	45		
5/4/00 – Clarifier PACl	12	11*	1
5/4/00 – Clarifier FeCl3	12	12*	0
Coagulant PACl @ 1 meq/L (9 mg/L Al)	5	12	7
Coagulant FeCl3 @ 1 meq/L (18.6 mg/L Fe)	9	10	1
Blank	<4		
	Metal (µg/L Fe or Al)		
5/4/00 Inflow Fe	46.9		
5/4/00 Clarifier Fe	39.5	26.8*	
5/4/00 18600 µg/L Fe	2860		
5/4/00 Inflow Al	<8.0		
5/4/00 Clarifier Al	8.5	25*	
5/4/00 9000 µg/L Al	8060		

*The sample was allowed to settle before filtration

TABLE 2
TDP Loading and Reduction

Location I.D.	Total Dissolved Phosphorus Concentration (µg/L P)				
	$FeCl_3$ 1.5 meq/L (27.9 mg/L Fe)		PACl 2.9meq/L, (26 mg/L Al)		$FeCl_3$ 2.5 meq/L (46.5 mg/L Fe)
Influent	62		45		45
Influent + Coag.	70	80	60	80	70
Clarifier	25	25	12	12	12
Influent Reduction (µg/L)	37		33		33
Influent + Coag. Reduction (µg/L)	45	55	48	68	58
Influent Reduction (%)	60		73		73
Influent + Coag. Reduction (%)	64	69	80	85	83